

Proposal: Optical Fiber in High-Cost and Rural America – Connect America

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(GN Docket nos. 10-90 and 13-5) March 7, 2014

This is a proposal to conduct experiments, with the Commission's oversight, to evaluate the potential impact on enduring Network Values - "public safety, universal service, competition, and consumer protection" - when providers use a new technology in the fixed wired access network in high-cost and rural America to deliver the Universal Service. The experiment will involve the deployment of fiber-based network (FTTH/P) in a "new-build" (green-field) deployment and upgrades of the existing networks in a brown-field from copper-based to FTTH/P network using new innovative low cost and low power consumption optical technologies delivering universal voice service, and providing a future-proof access network with more than 30,000 GHz bandwidth per customer of optical fiber over 10 km range. The experimental results will be used to develop business model for deploying optical fiber networks in rural, high-cost areas and should provide ideas and information to policy decisions.

The FC goals and definition of universal service and modern networks is extracted below from the "USF/ICC Transformation Order (November 2011)":

The adopted goals are: (1) preserve and advance universal availability of voice service; (2) ensure universal availability of modern networks capable of providing voice and broadband service to homes, businesses, and community anchor institutions; (3) ensure universal availability of modern networks capable of providing advanced mobile voice and broadband service; (4) ensure that rates for broadband services and rates for voice services are reasonably comparable in all regions of the nation; and (5) minimize the universal service contribution burden on consumers and businesses.

Carriers that elect to receive Connect America Fund must provide broadband with actual speeds of at least 4 Mbps downstream and 1 Mbps upstream, with latency suitable for real-time applications and services such as VoIP, and with monthly usage capacity reasonably comparable to that of residential terrestrial fixed broadband offerings in urban areas. In addition, to ensure fairness for consumers across the country who pay into USF, we reduce existing support levels in any areas where a price cap company charges artificially low end-user voice rates.

***Voice Service:** To promote technological neutrality while ensuring that our new approach does not result in lower quality offerings, we amend section 54.101 of the Commission rules to specify that the functionalities of eligible voice telephony services include voice grade access to the public switched network or its functional equivalent; minutes of use for local service provided at no additional charge to end users; toll limitation to qualifying low income consumers; and access to the emergency services 911 and enhanced 911 services to the extent the local government in an eligible carrier's service area has implemented 911 or enhanced 911 systems.*

The nature of the submitting entity:

Chaltel Ltd. is a consultancy based in London/United Kingdom. Dr. Salah Al-Chalabi has more than 25 years of experience in the telecommunication sector with extensive knowledge of R&D, technical and business strategy as well as telecommunication regulations in the USA and the European Union. He is the inventor of new innovative optical communication system.

Identification of the proposed service area for the experiment:

The arenas in which the experiments can be conducted include:

- different population density and demography: urban, suburban and rural areas
- different geographical area: plane, hilly, mountainous, remote islands
- different climate: cold, hot moderate, humid, dry, tornado, hurricane ..etc.

The experiments can also be conducted in areas with different status of network deployment;

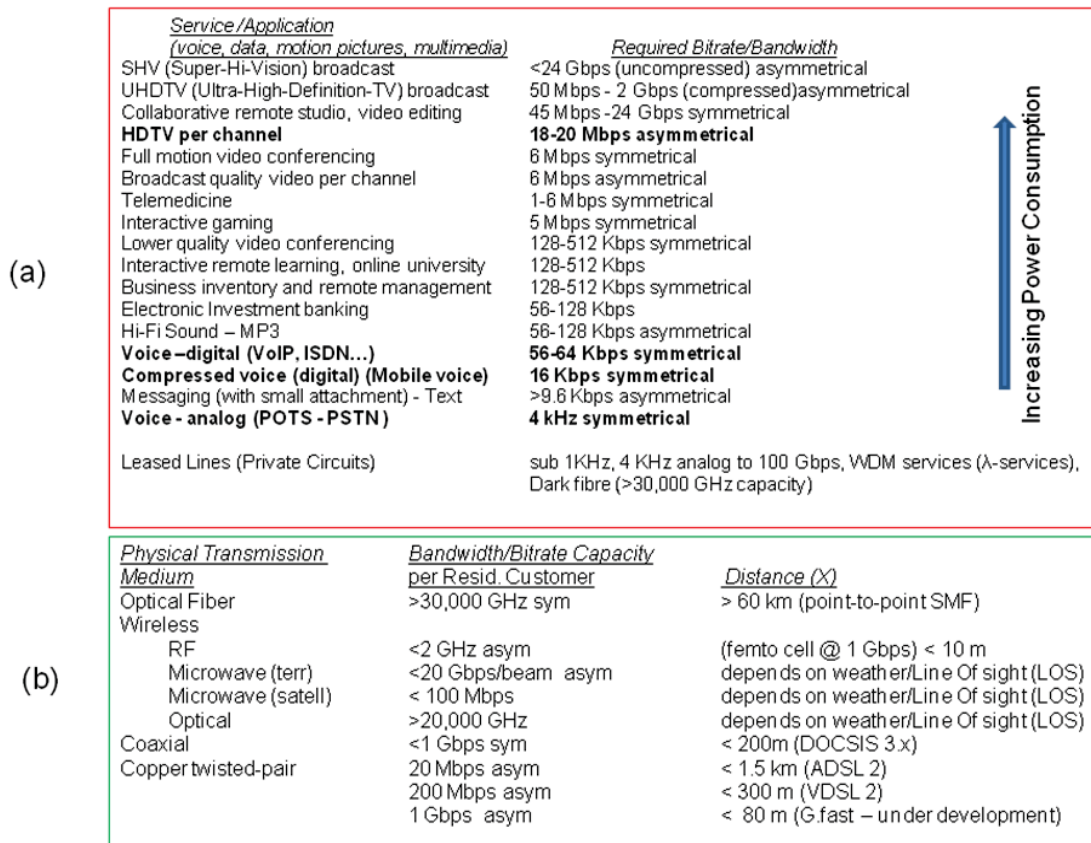
- green-field or “new-build” deployment, where no other fixed network exists
- brown-field deployment, where a legacy network already exists, but needing upgrades or replacement

The broadband technology or technologies to be deployed:

The deployed infrastructure technology will be Fiber-To-The-Home/Premises (FTTH/P) of bandwidth of more than 30,000 GHz over a distance of 10 km. Proprietary non-standard terminal equipment at the Central Office (CO) and Customer Premises Equipment (CPE) that can deliver regulated voice, broadband, and HDTV will be used. The voice circuit of the CPE will be optically powered from the CO to ensure continuous availability of access to emergency services in case of power outage at the Customer Premises (CP). The broadband, HDTV, and other equipment will be locally powered, as they consume more power than can be delivered over optical fiber. The terminal equipment can be upgraded to deliver high data rate services of 10, 100, and 1,000 Mbps exploiting the more than 30,000 GHz bandwidth of optical fiber over more 10 km range. This should meet all the goals of the *USF/ICC Transformation Order*.

Contemplated service offerings:

The proposed FTTH/P technology can deliver all the services shown in figure 1a, which shows the different telecommunication service and the bandwidth or transmission rate required starting from 4 kHz for universal Plain-Old-Telephony-Services (POTS) to 24 Gbps for SHV. The future-proof FTTH/P has more than 30,000 GHz bandwidth and can support all these services, and more. The experiment will offer regulated voice service, and symmetrical broadband service of 10, 100 Mbps and 1 and 10 Gbps, and HDTV services over distance of 10 km.



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Figure 1: (a) Telecommunication services and required bandwidth and transmission rate, (b) bandwidth and range of different channels - wireless, copper-based and optical fiber

State and/or local or Tribal governmental participation in and/or support for the project (e.g., expedited permitting, access to rights of way, matching funds, etc.):

Support from interested States, and Tribal governments will be sought.

High-level estimate of the amount and timing of required funding:

Building and deploying the innovative optical system will take 12 months and cost \$ 1,000,000. Extra funding will be required over six months to develop the business model for deploying these technologies in high-cost areas, rural America, and Tribal lands.

Statement of Purpose and Proposed Metrics

The experiment will focus on the deployment of robust, scalable optical fiber networks (FTTH/P) in rural, high-cost, and Tribal lands lacking Internet access that delivers 3 Mbps downstream/768 kbps upstream. The experiment will lead to better understanding of the viable business models that could support the deployment of fiber in all areas of the country.

The experiment will test the assumption among certain providers that the geographic and demographic characteristics of certain rural areas, including Tribal lands, economically preclude the deployment of high-capacity fiber-based services that deliver higher speeds to those communities. This should lead to ideas and information that will inform policy decisions regarding the deployment of next generation networks in rural, high-cost areas. The experiment will also examine the business case for optical fiber deployment in rural areas, including Tribal lands, by securing the participation of anchor institutions to serve as key customers of the next generation networks. Through these experiments, strategies will be identified to ensure that community-based institutions in rural areas, such as schools, libraries and health care providers, have access to next generation services delivered over optical fiber.

Proposed Metrics: The baseline of the proposed metrics will be those used to characterize legacy copper-based analog telephone service with centralized electrical powering, and xDSL or DOCSIS delivering broadband service less than 3 Mbps downstream/768 kbps upstream over 10 km range. These include:

- Reliability and integrity of FTTH/P network to deliver universal voice service
- Provision of HDTV and broadband services of symmetrical transmission rates of 10, 100, and 1,000 Mbps per customer over distance of 10 km.
- Validity of the innovative business strategy model enabled by the innovative technologies.

Technical Parameters and Timeline

Technology: Public network operators are upgrading their access network infrastructures (Figure 2a) to offer broadband services, HDTV, as well as regulated universal voice service (POTS). Copper twisted-pair connection can support up to 20 Mbps over a distance up to 1.5 km using ADSL 2 technology. Fiber-To-The-Cabinet/Node (FTTC/N), where fiber is deployed from the Central Office (CO) to the street cabinet which is then connected to the customer premises with copper twisted-pair or coax cable, can deliver 100 Mbps over a few hundred meters of copper wire, and up to 1 Gbps over 100 m. The power to the telephone CPE is supplied over the copper connection from the street cabinet to support the "lifeline". The optical transceiver is located in the street cabinet, and its cost can be shared among the customers served by the cabinet. However, the cabinet has to house active, environmentally hardened equipment requiring power supplied to the cabinet with backup batteries resulting in increased power consumption, installation, operating, maintenance cost, and reduced network reliability. FTTH is the ultimate future-proof solution, because optical fiber has the lowest losses and interference, and highest bandwidth (>30,000 GHz) that enables the delivery of any service that could conceivably be handled by a telecommunications network over distances of more than 10 km with comparable reliability and voice service availability to that over copper network. The experiment will demonstrate these benefits of innovative optical technologies satisfying universal service and network requirements.

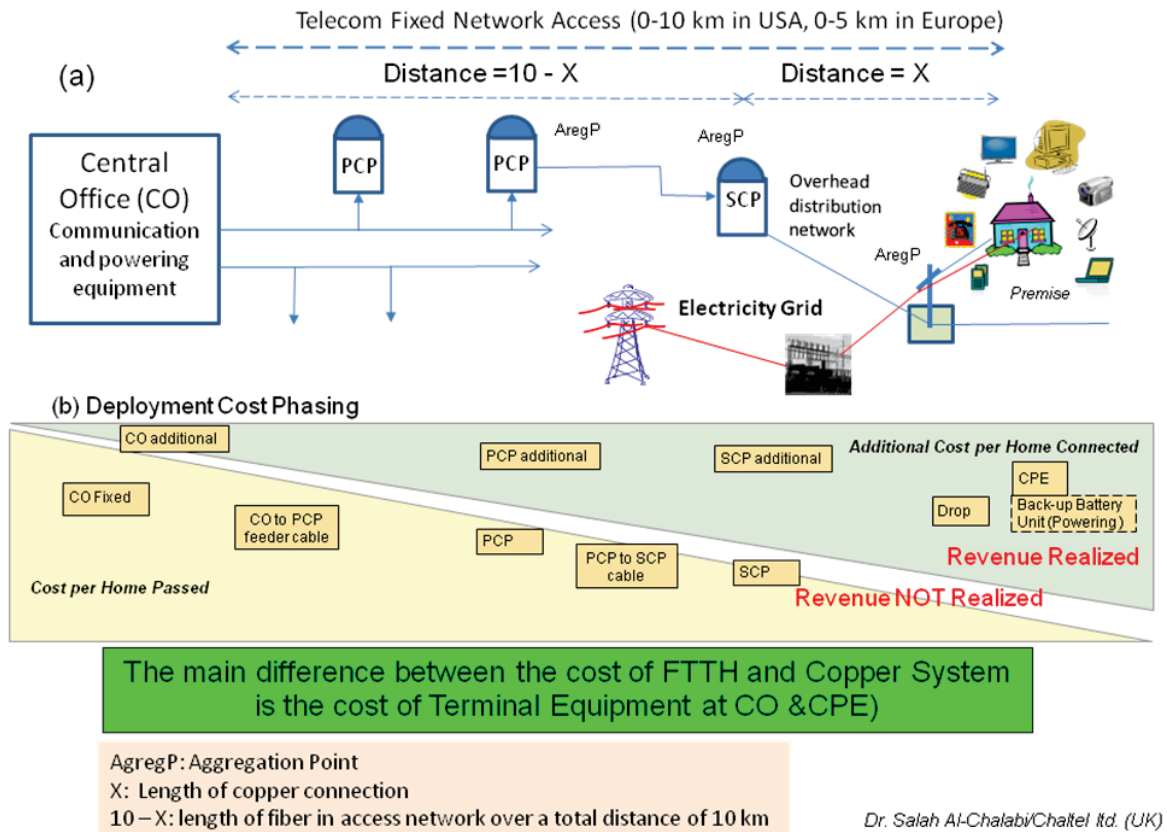


Figure 2: (a) Fixed access network architecture, (b) Upgrading deployment cost phasing

Business Model: The proposal also includes an assessment of the impact of low cost optical technologies on the business case for deploying optical fiber in high-cost and rural America. An investment is normally made to reap societal or financial benefits, and all investments have inherent uncertainty. An important part of any business case for investing in the access network is the financial analysis of the investment used to build or upgrade the different elements of the network, shown in Figure 2a, to deliver the different services.

A standard financial analysis of an investment value is based on cash flow over the investment lifetime. The financial value of the investment, shown in Figure 3, depends on the revenue per connected customer (Average Revenue per User - ARPU), and the cost per connected customer, which depends on the service take-up. The total cost is the sum of the capital expenditure (CAPEX) and the operating and maintenance cost (OPEX). The other factor is investment risk, which also depends on the service take-up.

The ARPU is normally set by the competitive market forces and regulations for regulated services. The main telecom services are: voice, data (narrowband, broadband, superfast broadband) and television. A list of the different telecom services and the bandwidth or transmission rate required for their transmission over a connection is given in figure 1a.

The main difference in CAPEX, Figure 3b, of delivering POTS over point-to-point FTTH and copper connections, especially in a "new-build" or "green-field" deployment, is the cost of the terminal equipment and powering the CPE. For instance, the capital installation cost of powering the current optical network termination (ONT) equipment, which requires a battery backup, ranges from \$45 to \$180, and the maintenance cost of an 8-h backup battery with life-time of 3–5 years is \$15-50 in materials and \$40 in labor. This should be compared to the cost of less than \$1 for a copper connection terminated at an RJ11 wall socket.

The main difference in OPEX, Figure 3c, between copper, FTTN, and FTTH/P networks is the maintenance and operating cost, including electricity cost and battery maintenance, of outdoor plant and equipment.

Figure 3a clearly shows that the value of investment decision also depends on the uncertainty in service take-up. The take-up rate of universal voice service is nearly 100 per cent, which eliminates the uncertainty in service take-up and investment risk in FTTH/p infrastructure of comparable cost to copper technology. Current optical technology fail to meet this cost target, which led to the deployment of FTTH/P mainly to compete by offering HDTV and superfast broadband service which have much lower take-up rate than voice service. To further minimize the risk of the initial cost, when the take-up is uncertain, is to phase the committed investment fund into two stages shown in Figure 2b: the passed and connected phase. Further cost reduction can be achieved with a single phase rollout in a neighborhood or district.

The lowest cost and investment risk deployment strategy of optical fiber is to install the regulated lifeline voice system over fiber infrastructure as a foundation, and add the superfast data and HDTV upgrades by mailing low-cost standardized “plug-and-play” CPE that can be installed by the customer with the help of technical support over the lifeline. This strategy should lead to much lower incremental cost than needed for copper-based systems. The upgrades can exploit the more than 30,000 GHz bandwidth of optical fiber over more than 10 km range.

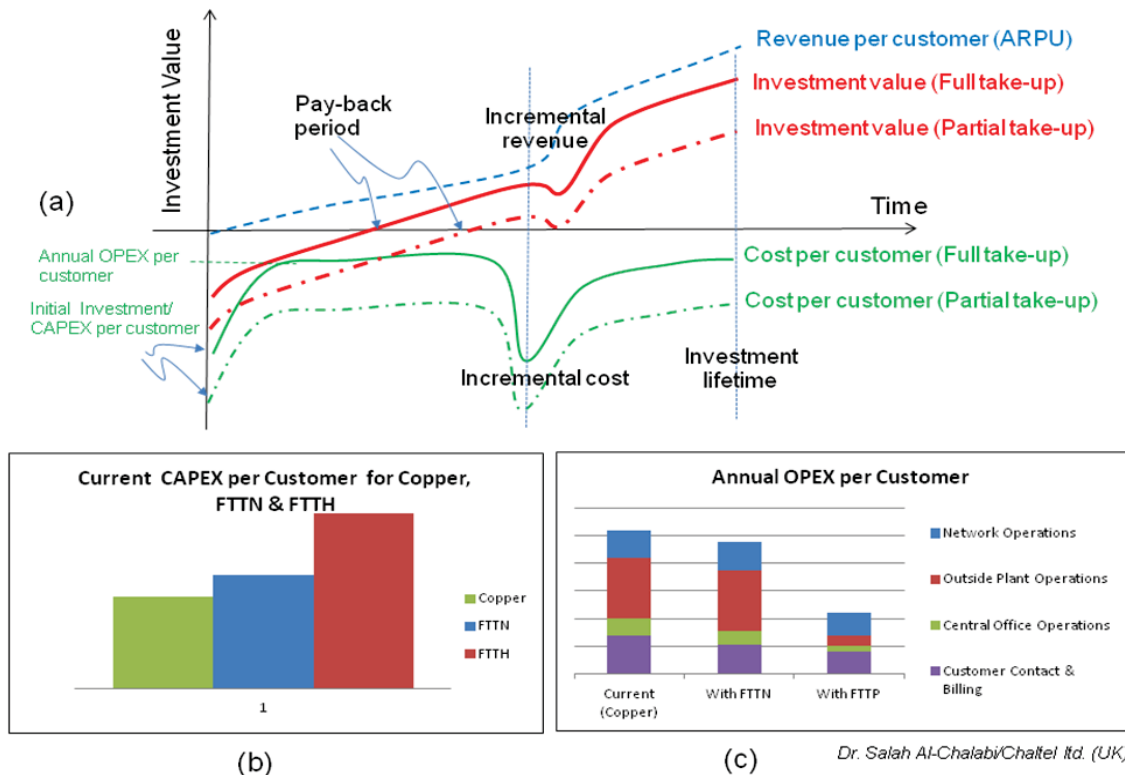


Figure 3: (a) The impact of incremental cost and incremental revenue on Investment value over time, (b) CAPEX per customer for different current access technologies, (c) OPEX per customer for different current access technologies

The decision by an incumbent provider to invest in an infrastructure will also depend on the investment already committed to provide the current services and the incremental cost required to provide a new service to generate new incremental revenue, as shown in Figure 3a. Other factors could influence the investment decision by a provider; such as competition, cost of finance, government funding and so on. Those factors will not be covered initially by the financial analysis of this proposal.

The project will develop the financial analysis for the strategies developed in this experiment to deliver the universal services and broadband networks specified in the *USF/ICC Transformation Order* over FTTH/P infrastructure using non-standard, low-cost, and low power consumption terminal equipment for the following scenarios:

	Competitive marketplace (more than one provider)				Non-competitive marketplace (at most one provider)			
	Urban	Suburban	Rural	Tribal	Urban	Suburban	Rural	Tribal
New-build network (Greenfield)	N	Y	Y	Y	Y	Y	Y	Y
Upgrading or replacing existing network (Brownfield)	N	Y	Y	Y	Y	Y	Y	Y

Timeline: Low power consumption optical communication system (less than 1 mW in the idle/quiescent state) with centralized optical powering is required to deliver the universal service and network capabilities specified by the *USF/ICC Transformation Order*. This system can be used over FTTH infrastructure suitable for rural areas with distance of 10 km. The technical design of the system is completed, and a system can be built and tested within 12 months.

Customer Participation

In principle, the experiments can be conducted without requiring existing customers to participate in the experiment, as the system performance will be compared to existing legacy system.

Regulatory Relief or Authorizations

To be determined.

Other Governmental Entities

To be determined.

A. Public Safety

Conditions

a. 911/E911 and Next Generation 911 Capabilities

The experiment will examine whether centralized optical powering architecture offers the same level of resilience, cost, reliability, and restoration time as legacy copper-based technology providing universal voice service with uninterrupted access to emergency services through 911/E911 in case of power outage. Centralized optical powering architecture sends optical power from the CO to the CPE over the fiber to power the telephone. Although the optical power is limited by the power handling capacity of the optical fiber, enough optical power can be delivered to operate the analog telephone to maintain reliable access to emergency services through 911 and support E911 service.

b. Safeguards to Ensure Public Safety Functionality in Adverse Conditions

In the event of public safety failure, the immediate restoration of legacy service, which is used as the baseline technology, is possible.

c. Protect Essential Communications Services for Safety of Life and National Security

During the experiment, essential national security and federal safety of life communications services are protected, as the technical transitions that are made to currently approved and deployed systems are immediately reversible if any deterioration in service occurs.

d. Network Security

The proposed experiment will compare the security of a point-to-point access network to a shared access network with point-to-multipoint or multipoint-to-multipoint architecture, which can further

reduce the cost of the physical layer. The security at the network level will be same as that for currently deployed networks.

e. Backup Power

One of the main objectives of the experiment is to assess the impact of technology transition from the current analog voice service over copper with centralized powering in the physical or network layers. The experiment will comply with backup power rules adopted in the 911 Network Reliability R&O. The experiment will evaluate impact of providing power backup for both facilities within the operator's network and for end-user equipment located at customer premises. The service quality and availability will be evaluated for a range of use cases involving commercial power outages of varying duration, i.e. ranging from a few hours to several days or weeks. The experiment will compare the services parameters for different technology transition scenarios.

f. Outage Reporting

Outage reports and PSAP notification will be filed complying with Part 4 rules that pertain to each legacy service being replaced during the experiment, regardless of the extent to which the rules would apply in the first instance to the type of IP-based service that replaces it.

g. CALEA Capabilities

The experiment will comply with the Communications Assistance for Law Enforcement Act (CALEA).

Presumptions

a. Network Reliability

The reliability of the proposed low power consumption optical communication system with centralized optical powering will be compared to current copper-based analog telephone with centralized electrical powering. This includes ability to function during commercial power failures and security from external attack. The best practice recommended by the Communications Security, Reliability, and Interoperability Council (CSRIC) will be applied during the experiment.

b. Provision of Public Alerts

The support of Wireless Emergency Alerts (WES) will be considered, and if difficult to achieve then application will be filed to rebut this presumption by providing notices of this non-election to affected customers and the Commission.

c. Public Safety Priority Services

The proposed experiment will have no impact on priority access, routing, provisioning, and restoration for essential national security and emergency preparedness communications. The experiment will not impact the Wireless Priority Service (WPS), Government Emergency Telecommunications Service (GET) and Telecommunications Service Priority (TSP).

B. Universal Access

The USF/ICC Transformation Order (2011) adopted goals: (1) preserve and advance universal availability of voice service; (2) ensure universal availability of modern networks capable of providing voice and broadband service to homes, businesses, and community anchor institutions; (3) ensure universal availability of modern networks capable of providing advanced mobile voice and broadband service; (4) ensure that rates for broadband services and rates for voice services are reasonably comparable in all regions of the nation; and (5) minimize the universal service contribution burden on consumers and businesses.

The Connect America Fund requires the provision of broadband with actual speeds of at least 4 Mbps downstream and 1 Mbps upstream, with latency suitable for real-time applications and services such as VoIP, and with monthly usage capacity reasonably comparable to that of residential terrestrial fixed broadband offerings in urban areas. The proposed future-proof fiber-

based (bandwidth > 30,000 GHz over 10 km) optical communications system is expected to satisfy, and surpass all these requirements.

1. Ensuring Access for Persons with Disabilities

The experiment will not jeopardize access to communications for persons with disabilities. The disability accessibility requirements mandated by statutes and Commission rules will be met, but if this proves difficult or impossible then a waiver from these regulations will be filled with the Commission.

The experiment will consider and study the impact of the technology transition on the provision of TRS, the transmission of remote closed captions, and the development and use of, and compatibility with assistive technologies.

2. Specific Populations

The experiments will be designed to protect the interests of specific vulnerable populations, such as the elderly, individuals with limited English proficiency (LEP), low-income populations, residents of Tribal lands, and others who likely will be affected by changes in communications technology in ways different from the general population. This will be achieved by deploying innovative, low cost technologies that deliver Universal Voice Service, and future-proof network with extremely high bandwidth (more than 30,000 GHz).

3. Maintain Universal Service Status Quo

The experiment will not deviate from any existing universal service rules and policies.

4. Preserve and Enhance Broadband Access

The bandwidth of an optical fiber is more than 30,000 GHz. The transition from copper-based to optical fiber-based physical layer with centralized optical powering that delivers the Universal Voice telephony service will provide a future-proof physical infrastructure in urban, suburban, and rural areas. The new optical technology should deliver voice service at comparable cost to copper based technologies, and lower incremental cost to deliver broadband services of 10, 100, and more than 1,000 Mbps exploiting the more than 30,000 GHz of optical fiber. The new and innovative optical technology provides levels of Internet access better than any other technology. The new technology will offer levels of universal voice service similar to legacy-based telephone service.

C. Competition

1. Wholesale access

The impact of deploying FTTH/P infrastructure delivering universal voice service on wholesale access will be assessed during the experiment.

2. Intercarrier Compensation

Intercarrier compensation will not be impacted by the experiment.

3. Interconnection

Interconnection will not be impacted by the experiment.

D. Consumer Protection

1. Customer Privacy

Consumer privacy will not be impacted by the optical technology used in this experiment.

2. Truth in Billing, Slamming, Cramming

The experiment will comply with the truth-in-billing rules, which are intended to address both slamming and cramming, and the Commission's other anti-slamming rules.

3. Local Number Portability

Local Number Portability will not be impacted by the optical technology used in this experiment.

4. Routing

Routing will not be impacted by the optical technology used in this experiment.

CUSTOMER NOTICE FOR SERVICE-BASED EXPERIMENTS

Notice to Customers: Participating and affected customers will be sent letters informing them about the experiments, and how they can choose to participate in the experiment voluntarily. The customer will be notified that the experiment is being conducted with the Commission oversight, and that the Commission encourages customers to provide feedback in this docket, and to provide the customers with instructions for doing so.

Notice of Network Changes: The information sent to the customer will include any relevant network changes and its timing, what features of the existing technology will no longer be available on the new technology and how that may impact third-party devices and services the customer uses (e.g., medical monitoring services); how the services will change including any differences in how applicants will provide their customers adequate notice of and information about the experiments.

DATA COLLECTION AND REPORTING (Docket 13-5)

The data collected from the experiment will help to understand how it relates to the enduring values embodied in the statute. To foster a robust public discussion about the impact of technology transitions that is fact-based and data-driven, the results of this experiment will be “open data” so that data are publicly available, or made available pursuant to protective order against non-disclosure as appropriate.

The data will include key attributes of services, including IP-based, such as network capacity, call quality, device interoperability, service to persons with disabilities, system availability, 911 and PSAP service, cybersecurity, call persistence, call functionality, and service coverage, impact of the transition on people with disabilities and other specific populations, such as consumers living on Tribal lands. Consumers’ experiences during the experiment will be measured using a questionnaire. The experiment will include a “control group” already provided with copper-based analog telephone with average (4 Mbps downstream 1 Mbps upstream) broadband connection. The control group will be within the same geographic area, such as a wire center, as the experimental group. Collected data in the experiment or non-experiment areas will be clearly indicated.

All data related to public safety, law enforcement, cybersecurity, and national security will be clearly marked. The data will clearly measure the transition’s impact on government functions (e.g., police, fire, Emergency Medical Services (EMS), or the Federal Aviation Administration (FAA) or Department of Defense (DoD)), consumers’ ability to access 911 and other emergency services, other public safety and security requirements currently performed by traditional PSTN systems, including 911 calls; CALEA requirements; internally and externally caused network outages or disruptions to service; and ability to meet cybersecurity or other threats and disasters.

The data will be submitted in a manner that ensures protection of customer privacy consistent with applicable privacy laws and regulations. Information or records that are subject to laws or regulations related to customer proprietary network information (CPNI), will not be submitted. In addition, the applicability of other privacy protections, including the Electronic Communications Privacy Act as well as the prohibitions related to customer privacy described in 47 U.S.C. § 551 will be complied with.

The economic impact of the transition from copper based to fiber-based (more than 30,000 GHz bandwidth) physical layer offering access to all foreseeable Internet and HDTV services and the will be assessed.